Advanced Communication Systems

420 –520 Transmitter
Operating Manual

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UHF Transmitter
420 - 520 MHz
Operating Manual

Issue 2001

- ADVANCED COMMUNICATION SYSTEMS •

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DESCRIPTION

The ACS 450T is a solid-state FM transmitter capable of operating on any crystal-controlled single-frequency in the 406–512 Mhz range. The ACS 450T is engineered for high reliability to provide maintenance free operation in repeater and base station applications. The transmitter may be configured to operate at output power levels of 2 to 15 watts.

Transmitter circuitry is contained on two printed circuit boards mounted in a 6-inch (15.2 mm) x 6-inch (15.2 mm) x 2-inch (5 mm) aluminum enclosure. One circuit board contains audio, modulator, oscillator, multiplier, and driver stages plus the low power (2-watt) amplifier. The second board contains the high power (10-15 watt) TMOS FET amplifier. All non-RF leads entering the transmitter enclosure are by-pass filtered with individual feed-through capacitors. RF output energy is delivered through an enclosure mounted type N coaxial connector.

Notice

The commercial version of the ACS 450T transmitter is type accepted for operation under FCC Regulations parts 90 and 95. The transmitter may be operated only in accordance with an authored station license issued under those regulations. A licensed technician must make installation and adjustment of the transmitter.

Advance Communication Systems limits its liability with respect to the ownership and operation of this equipment as described in the warranty section of this manual. By installing and/or operating this equipment the owner signifies acceptance of these limitations.

1.0 SPECIFICATIONS

• **Frequency range:**	**406 – 512 MHz**
• **Power output exciter:**	**Adjustable from .5 to 2 watts**
• **Power output amplifier:**	**TMOS FET provides 10 to 15 watts output, capable of withstanding high VSWR in case of antenna or feed line problems.**
• **Frequency control:**	**Parallel resonant crystal - 32pf load capacitance in HC-25/U holder. Optional proportionally controlled oven available (standard on commercial version).**
• **Multiplication ratio:**	**24 x**
• **Frequency stability:**	**+/- 00.00025% (-30° to + 60° C)**
• **Harmonic output:**	**Greater than 65 dB below rated output**
• **Spurious output:**	**Greater than 70 dB below rated output**
• **Noise output:**	**Greater than 90 dB below rated output in high-power mode at +/- 5MHz from output carrier frequency**
• **Modulation:**	**Frequency modulation. Deviation adjustable to +/- 5KHz**
• **Audio Response**	**Within +2 dB, -3 dB of EIA standard 6 dB/octave pre-emphasis from 300 Hz to 2700 Hz**
• **Audio Distortion:**	**Less than 2%**
• **Power Requirements**	**Exciter - 12 to 15 VDC @ .5amps** **Amplifier – 12 to 28 VDC** **1.5A @ 12v 2 A @ 24 v**
• **Duty Cycle:**	**Continuous**
• **FCC Identifier**	**D4D6NA-MT45OB**
• **Emission designator**	**5F3**

2. INSTALLATION

2.1 Operating Location

As with any electronic equipment, selecting a location that will not subject the unit to extreme environmental conditions will enhance the reliability of the transmitter. The location should be chosen such that the transmitter will not be exposed to moisture or a corrosive atmosphere.

2.2 Mounting

The unit may be mounted in any position. Removal of the top cover is required to make adjustments, so allow sufficient clearance when mounting. The transmitter enclosure provides sufficient heat sinking in most cases. In those cases where ventilation is inadequate, the transmitter enclosure should be mounted firmly to an equipment rack panel or other supplemental heat sink to ensure that the transmitter internal ambient temperature does not exceed 60°C.

2.3. Connections – General

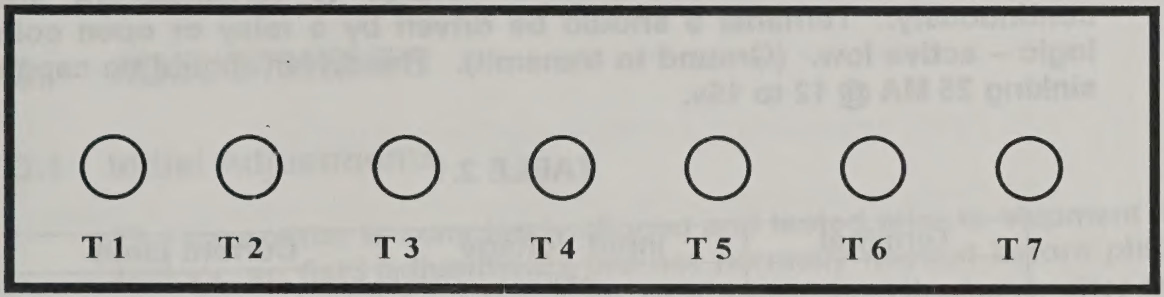
Connections are made to the feed-thru capacitors by soldering directly to the terminals. RF output is taken from the connector that is located on the rear of the transmitter enclosure. Positions of the terminals are shown in figure 2.1.

•IMPORTANT•

CONNECT AN ANTENNA OR DUMMY LOAD BEFORE APPLYING POWER.

Figure 2.1

Enclosure assembly showing terminal locations



T 1	Ground Terminal (when provided)
T 2	Relative RF output
T 3	12-28 volts DC – 1.5 amps @ 12 v 2 amps @ 24 v
T 4	+12 – 15 VDC – 500 MA XMIT - 20 MA idle
T 5	PTT – Active low – 25 MA
T 6	Audio input approximately 400 MV peak to peak
T 7	CTCSS encode input (when provided) (approximately 250 MV required peak to peak)

2.4 Power Connections

The supply should be well filtered DC source capable of the required current. Connect the positive voltages as shown in the table and ground the negative lead to T1.

- **DO NOT GROUND TERMINAL 5 UNLESS A PROPER ANTENNA OR DUMMY LOAD IS CONNECTED.**

Connect the positive voltage inputs to the transmitter terminals shown in the table 2.1 and the negative lead to the transmitter ground terminal T1.

Observe the correct polarity, otherwise damage to the transmitter or power supply will occur. Power connections should be fused to limit the maximum current to the values shown in the table.

The power source should provide voltage to terminals T4 and T2 continuously. Terminal 5 should be driven by a relay or open collector logic – active low. (Ground to transmit). The driver should be capable of sinking 25 MA @ 12 to 15v.

TABLE 2.1

Terminal	Input Voltage +DC	Current Limit
T 4	+12 to +14	500 MA.
T 5	GND	25 MA.
T 2	+12 to +30	1.5 A – 2A

2.5 RF Output

RF output from the transmitter is taken from the type UHF coaxial connector J1. Connection should be made from J1 to a 50 ohm antenna system using a 50 ohm coaxial cable. For proper operation, the antenna system VSWR should not exceed 1.3:1.

2.6 Audio Input

The audio input required is approximately 400 milivolts peak-to-peak from a nominal 1000 ohm audio source. Connect the audio input to transmitter terminal T6. Shielded wire should be used for making this connection.

Grounding problems in some installations may cause hum and noise pickup on wiring between the audio source and the transmitter.

In these cases, ground the shield only at the audio source. Make no connection from the shield to the transmitter. If the audio source is separated from the transmitter by a long distance, connecting the shield to the transmitter ground through a small capacitor, approximately .001 uF, may minimize noise.

2.7 CTCSS (optional)

In applications where Continuous Tone Coded Squelch (CTCSS) is used, audio from an external CTCSS encoder should be applied at transmitter terminal T7. The signal applied to this input must be a single-frequency tone with a sinusoidal waveform having less than 10% distortion. The encoder should have an output amplitude of approximately 250millivolts peak to peak. See section 3.4 - CTCSS level adjustment.

3. ADJUSTMENTS

3.1 Initial Adjustments

The transmitter is completely aligned and tested prior to shipment from the factory, so field adjustments are not normally needed before placing the transmitter in service. However, as a precaution, the transmitter deviation and frequency should be checked to verify that these adjustments were not affected during shipment. Procedures for checking deviation and frequency are given in sections 3.1 and 3.3 respectively.

The transmitter is tuned at the factory to operate into a 50ohm resistive load. For proper operation, the antenna and/or duplexers connected to the transmitter should be adjusted to present a 50ohm termination to the transmitter. If the antenna system cannot be tuned to obtain an ideal 1:1 VSWR, a slight adjustment of the transmitter output amplifier stage may be necessary as described in section 3.5.

- It is strongly recommended however, that antenna or feed line problems should be resolved by repairing or replacing the defective component, not retuning the transmitter.

3.2 Deviation Adjustments

The modulation level was adjusted prior to shipment from the factory to provide 5 kHz deviation at 400 MV peak to peak audio input. The transmitter limiter will allow this full deviation level to be reached on voice peaks over a wide range of audio input levels. Transmitter deviation may be adjusted as follows:

Test equipment required:

- Nominal 1000 ohm impedance sine wave audio oscillator
- Communications test set or modulation meter
- RF dummy load

Procedure:

1) Connect the audio oscillator to transmitter terminals T6 (audio) and T1 (ground). Adjust the audio oscillator to provide a 400-milivolt peak to peak, 1000 Hz output signal.

2) Connect the transmitter RF output (J1) to the dummy load.

3) Apply operating DC voltages to the transmitter.

4) Measure the transmitter deviation using the modulation meter.

5) Use a fine blade screwdriver to set the DEVIATION ADJUST (R20) to obtain 5kHz deviation.

3.3 Audio Level Adjustment

Audio level is an EXTERNAL adjustment - no internal audio level adjustment is provided. Transmitter deviation must be set (per section 3.2 above) before adjusting the audio level. Input audio level should be adjusted so that occasional voice peaks produce a full 5kHz deviation. The transmitter limiter will prevent excessive transmitter for any audio input level setting; however, improper settings will degrade performance by emphasizing background noise and distortion.

Test equipment required:

- Communications test set or modulation meter
- RF dummy load

Procedure:

1) Connect audio source to be used to transmitter terminals T6 (audio) and T 1 (ground).

2) Connect the transmitter RF output (J1) to a dummy load.

3) Apply operating DC voltages to the transmitter and ground T5.

4) Speak into the microphone in a normal voice.

5) Measure the transmitter deviation using the modulation meter.

(Continued on page 10)

6) Adjust the input audio level control so that the audio peaks indicate 5kHz deviation on the modulation meter.

- **DO NOT ADJUST THE TRANSMITTER DEVIATION SETTING.**

3.4 Frequency Adjustment

Test equipment required:

- Frequency counter of 2 ppm accuracy
- RF dummy load

Procedure:

1) Remove the four screws holding the transmitter top cover and remove the cover.

2) Connect the transmitter RF output (J1) to a dummy load.

3) Key transmitter and let operate at normal power for at least 5 minutes to stabilize component temperatures.

4) Loosely couple an insulated wire loop from a frequency counter to the transmitter harmonic filter line.

5) Rotate C27 using an insulated tuning tool to set the transmitter to the correct frequency as indicated on the frequency counter.

6) Remove the wire loop and replace the transmitter top cover.

3.5 CTCSS level Adjustment (optional)

In applications where Continuous Tone Coded Squelch is used, tone encoder amplitude should be adjusted to properly modulate the transmitter (generally 250 - 500 Hz).

(Continued on page 11)

Test equipment required:

- Communications test set or modulation meter
- RF dummy load

Procedure:

1) Connect the CTCSS encoder to transmitter terminals T7 (tone) and T 1 (ground)

2) Connect the transmitter RF output (J1) to dummy load.

3) Apply operating DC voltages to the transmitter.

4) Insure that no audio is being applied to transmitter terminal T6.

5) Measure the transmitter deviation using the modulation monitor.

6) Adjust the CTCSS encoder level to obtain an indication of 500 Hz deviation on the modulation monitor. DO NOT adjust the transmitter deviation setting.

3.6 Alignment

The transmitter is completely aligned prior to shipment from the factory. Alignment should only be necessary due to component replacement or aging. Transmitter frequency (see 3.4) and deviation (see 3.2) should be checked following any repair or change in frequency.

Test equipment required:

- 20,000 Ω/V multimeter having a 0-10 volt scale
- 0-2A current meter
- RF dummy load
- RF power meter

Procedure: 2 watt Exciter Board adjustment

1) Remove the four screws holding the transmitter top cover and remove the cover. Remove 24v supply from T2 (see page 6).

2) If the unit is wired for high power operation, disconnect the PA board output coax now connected to J1. Then remove the exciter coax

cable from the input to the PA board and connect it to J1. (This will assure the exciter is tuned to a 50ohm load.)

3) Connect the transmitter RF output (J1) through the RF power meter to a dummy load.

4) Apply +12 to 15 volts to transmitter terminal T4 and Ground T5.

5) Adjust R58 fully clockwise. Connect a voltmeter between ground and each test point (TP) shown in table 3.4. Adjust the circuit components shown in the table to obtain maximum reading on the meter. Some interaction will occur, so repeat the adjustments as necessary until no further increase can be obtained. The output power should be approximately 2 watts with R58 fully clockwise.

6) Remove power, lift ground from T5 and reconnect the coax cables as original. Proceed to PA alignment.

Table 3.4

Test Point	Nominal Voltage	Adjust Components
	+DC	
TP3	4	L2, L3, C46
TP4	5.6	L4, C52, L5, C54
TP5	3.2	L6, C58, L8, C61
TP6	2.2	L10, C67, L11, C69

PA Alignment

1) To set bias, make sure the RF meter and dummy load are connected and apply +12 v and +24 v. Do not ground T5. Connect and ammeter (0-2A scale) in the 24v line to monitor final current. Connect a voltmeter to the gate (input) of FET Q101. Adjust control R103 to obtain a reading of approximately 20 MA on the ammeter (approximately 2.7-3.0 volts).

2) Turn R58 fully clockwise (maximum power output) and ground T5.

3) Adjust capacitors C1 and C7 to achieve maximum indication on the RF output meter. Some interaction will occur, so repeat the adjustments until no further increase can be obtained.

(Continued on page 13)

4) **Adjust control R58 to obtain the desired output on the RF power meter. Observe the ammeter - the final amplifier current should not exceed 1.5 A. Adjust R58 if necessary to prevent the current from exceeding 1.5 A.**

5) **Replace the transmitter top cover. This completes the alignment of the transmitter for high-power (10 to 15 watts) operation.**

4. CRYSTAL

4.1 Crystal Specifications

The transmitter is shipped from the factory with the frequency controlling crystal installed and with the transmitter tuned to frequency. If the transmitter frequency is to be changed, the replacement crystal unit should conform to the following specifications:

Crystal frequency: (Transmitter operating frequency) / 24
Mode: Parallel resonant, 32pf load capacitance
Type: High-accuracy, 60°C turnover,HC-25/U holder

4.2 Crystal Replacement

1) **Remove all power from the transmitter.**

2) **Remove the four screws holding the transmitter top cover and remove the cover.**

3) **Remove crystal and replace. See section 3.4 to set frequency.**

4) **When supplied with crystal oven, the following procedure must be followed. NOTE: the oven is POLARIZED, therefore careful attention must be paid to installation.**

5) **Remove the four screws securing the exciter circuit board and carefully lift the circuit board to gain access the bottom.**

6) **Locate the crystal heater unit and observe its' orientation. Unsolder the two wire leads holding the heater unit to the circuit board and remove it.**

(Continued on page 14)

CAUTION: Use a fine point temperature controlled soldering iron and a solder wick or de-soldering tool. Apply the minimum heat necessary. Do not exert excessive stress on component leads.

7) Unsolder the two wire leads holding the crystal and remove it.

8) Install the new crystal in place, and then replace the heater unit. IMPORTANT- be sure to position the heater unit in its original orientation – it is polarized and will be damaged if improperly installed.

9) Replace the exciter circuit board and secure it in place with the mounting screws.

This completes the crystal replacement procedure. The frequency MUST now be adjusted (see section 3.4).

5. Low Power Operation

If it was originally supplied for high power operation, the transmitter can be arranged to operate in a low power mode for use in applications where the maximum permitted output power is 2 watts. The wiring changes needed to operate in the low power mode are as follows:

Caution: Remove power from the transmitter before making wiring changes.

1) Remove the coaxial cable connecting from the power amplifier board to RF output coaxial connector J1.

2) Locate the coaxial cable connecting the exciter board to input terminal on the power amplifier board and disconnect the cable from the input of the power amplifier board. Connect the free end of the coaxial cable to the RF output coaxial connector J1.

Power amplifier stage Q101 is not used in the low power mode, therefore no power connection should be made to terminal T2. After the wiring changes are made, the transmitter should be aligned in accordance with the procedure given in section 3.6 for low power operation. Power Adjust potentiometer R58 should be used to set the transmitter output power for your requirements.

6. Circuit Description

6.1 Audio Amplifiers

Input audio is applied to the transmitter through feed-thru capacitor T6 Additional RF bypassing is provided by capacitor C1. The 1K ohm audio input impedance is established by resistor R1. Audio signals are amplified in operational amplifiers U1A. The two amplifier stage is AC coupled, and the output is biased at level of +6 VDC. Feedback is provided by capacitor C3 to control the frequency response of the amplifier. Supply voltages to the amplifiers are decoupled to prevent noise pickup with ferrite bead FB2 providing high-frequency decoupling and R7/C7 providing low-frequency decoupling. Amplifier bias is established by resistive divider R2 and R3 with bead FB1 and capacitor C4 providing decoupling. Audio output from U1A is applied to the limiter stage through resistor R9.

6.2 Limiter, post limiter filter

Integrated circuit U2A contains an audio amplifier and a variable gain cell that serves as both a compressor and peak limiter. Input audio is applied to pin 5 of U2A and output audio is taken from pin 7. DC feedback is provided by R11 and AC feedback is provided by C10 in combination with the internal circuitry of U2A. The gain of U2A is controlled by the voltage present on capacitor C13. At low audio levels the voltage present on C13 is small so U2A operates as a linear amplifier. The output of U2A is sampled and further amplified by U3. The output of U3 is fed to Q1. At high audio levels, Q1 causes the voltage across capacitor C1 to increase and thereby reduces the gain U2A. The adjustable gain cell in U2A operates in a logarithmic manner to accommodate a wide dynamic range of audio levels. In normal operation where the transmitter deviation is set to a maximum of 5 kHz, U2A functions as a linear amplifier. For audio levels that produce less than 4.8 kHz deviation, compression starts, and in the hard limiting region, the output is held constant for input drive levels greater than 20 dB over normal peaks.

The output of U2A is fed to deviation adjust potentiometer R20 and then to the post limiter audio filter consisting of R21, R22, R23, C15, C16, C17, and C19. The post limiter filter provides a minimum of 18 dB per octave rejection of signals above 3kHz. The output of the post limiter filter is fed to voltage amplifier Q2 that drives varactor diode CR1 to deviate CR1 to frequency modulate the transmitter.

6.3 Oscillator, buffer

Transistor Q3 and associated components form a Colpitts oscillator. Feedback to sustain oscillation is provided by capacitors C33 and C34. Stable silver mica capacitors are used to maintain a precise feedback ratio. The voltage applied to Q3 is maintained precisely by voltage regulator VR1 to enhance oscillator stability. The frequency of the oscillator is determined primarily by crystal Y1. Variable capacitor C27 is in series with the crystal and permit a small range of adjustment to the transmitter frequency.

Audio voltage from U1B applied to CR1 causes a corresponding change in diode capacitance that produces frequency modulation of the oscillator.
Crystal Y1 may be mounted in a proportional oven to prevent variations in ambient temperature from changing transmitter frequency (This is an option on units built for amateur service).

Output from the oscillator is fed to buffer amplifier Q4. The buffer amplifier acts as a constant load to isolate the oscillator from changes as the multiplier stages are tuned. A test point, TP1, is provided at the emitter of buffer amplifier Q4. A nominal voltage of 1.7 VDC at this test point signifies that the oscillator and buffer stages are operating properly.

6.4 Multipliers

Four stages are used to multiply the oscillator fundamental frequency to the final output frequency. The four stages provide a multiplication ratio of 24. Each stage consists of a transistor followed by a double-tuned interstage filter. Double-tuned interstage networks provide increased rejection of unwanted harmonics compared with single tuned networks. In addition, the double-tuned stages give reduced sensitivity to temperature variations and component aging. The four multiplier stages are as follows:

Multiplication Ratio	Transistor	Output Frequency Range in MHz	Interstage Filter
3	Q5	50.5 – 64	L2, L3, C46
2	Q6	101.5 – 128	L4, C52, L5, C54
2	Q7	203 – 256	L6, C58, L8, C61
2	Q8	406 - 512	L10, C67, L11, C69

Test points are provided at the emitter of each multiplier stage to aid in alignment and troubleshooting. DC voltage measurements at the test points are used to align the double-tuned networks of the preceding multiplier stage as described in section 3.6.

6.5 RF Amplifiers

Amplifier Q9, Q10, and Q11 operate at the transmitter output frequency. Q9 is a pre-driver amplifier with a single-tuned output network consisting of L13 and C74. Test point TP6 at the emitter of Q9 to aid in the alignment of the preceding doubler stage Q8. R58 adjusts the collector voltage of Q9 thereby setting transmitter output power.

Transistor Q10 provides drive to the final low-power output stage. Q10 is tuned by L16 and C78. Series capacitor C79 and shunt inductor FB20 provide impedance matching from the output of Q10 to the input of amplifier Q11.

Amplifier transmitter Q11 increase the transmitter power level to the 2-3 watt range. The tuned output network of Q11 consists of inductors L20 an L11, and capacitors C86, and C87. This output network provides both low-pass filtering and impedance matching to a 50 ohm load.

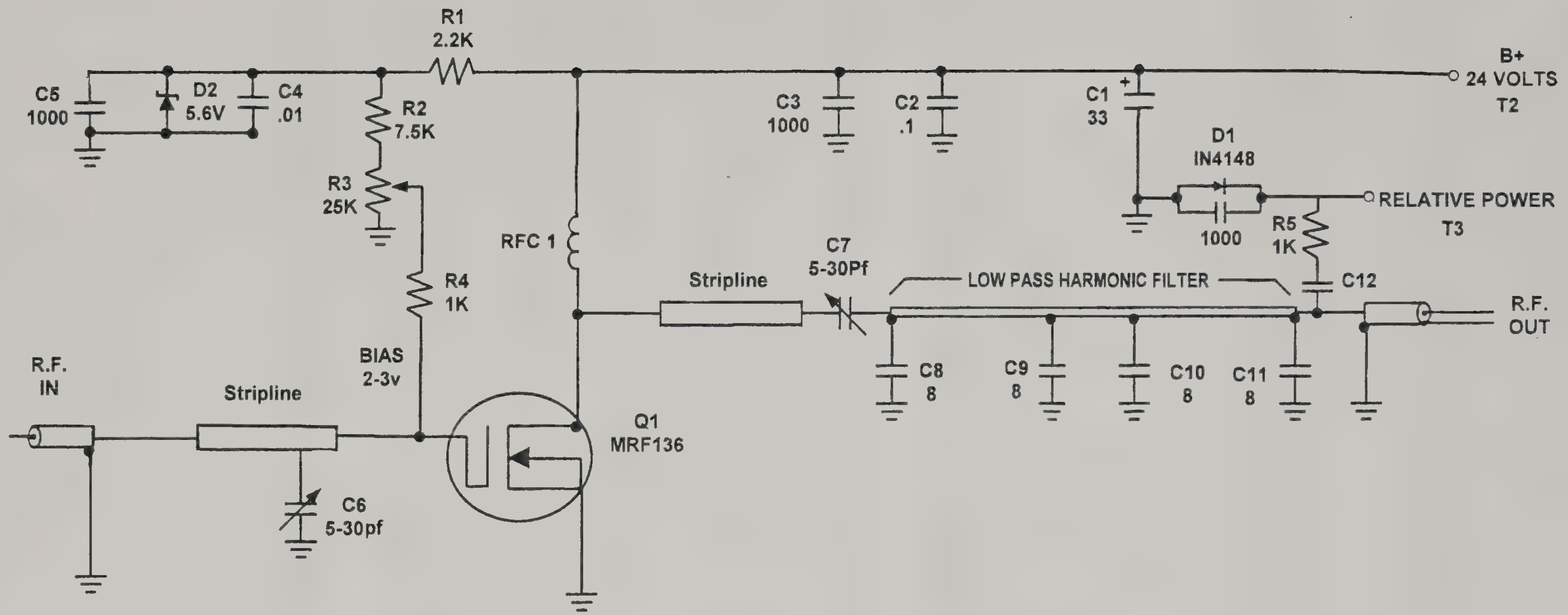
6.6 Power Amplifier

For high-power operation TMOS FET power amplifier transistor Q101 raises the transmitter output power to 10-15 watts. Q101 operates at a nominal drain supply voltage of +28 volts and a gate bias of approx. 3 volts. Gate bias is achieved using voltage regulator CR101 to develop a stabilized voltage and potentiometer R103 to adjust for variations in transistor characteristics.

The input of Q101 consists of a stripline filter tuned by capacitor C1. The output of Q101 is a similar stripline tuned by capacitor C7. The harmonic filter is a four-section network that provides excellent rejection. Output power is sampled by capacitor C12 and rectified by diode D1 to provide a relative output power level at terminal T3.

6.7 Power Distribution

The unit has two separate power supply inputs: a continuous +12 volt input and a continuous +28 volt input. The continuous +12 volt input powers buffer Q4 and is regulated down to +8 volts by VR1 to power oscillator Q3. Multiplier, driver, and amplifier stages Q5 through Q11 are powered from the switched +12 volt line. The +28 volt supply is used only for high power operation and supplies Q101. Power supply decoupling, in the form of RLC filter networks, is used on all active stages.



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PA - 15 - 450 Schematic

All capacitors in pf except C33
and decimal values are in uf.

7. Maintenance

The transmitter is designed and constructed for reliable operation and long-life. Periodic maintenance is not required.

- If the transmitter fails to operate, verify that the two power supply voltage sources are connected to the transmitter and that the correct voltages are being supplied. Also, verify that the transmitter is properly grounded.

- The transmitter can be damaged by lightning induced surges. Failure of the transmitter to draw current from the +28 volt supply is an indication that amplifier Q101 may have been damaged by a lightning surge.

Limited Warranty

Advanced Communication Systems warrants to the original purchaser that this equipment shall be free of defects in material and workmanship for one year from the original date of purchase.

During the warranty period, ACS will provide any parts necessary to correct said defects provided the unit is delivered by the original owner intact to us for our examination and provided that our examination discloses that the unit is defective.

This warranty does not apply to any unit that has been subjected to misuse, neglect, accident, improper installation, incorrect maintenance, or use in violation of instruction furnished by us, nor to any unit that has been modified or used with accessories not recommended by us. Damage due to lightning is not covered.

The foregoing constitutes the entire obligation of ACS with respect to this product and no employee or officer of ACS or any of its'dealers or distributors shall have the authority to extend or modify this warranty. The buyer agrees that no other remedy for incidental or consequential damages, injury to person or property, or other loss shall be available. Some states do not allow limitations as to how long an implied warranty lasts or on consequential damages, so the above limitations may not apply to you.

The installation, operation, and maintenance of this unit may require licensing by the Federal Communication Commission or other regulatory agencies, and may require that adjustments to the unit be made by a licensed technician. The proper and legal operation of this unit is the responsibility of the owner.

ACS reserves the right to make changes and improvements to its products without notice and without obligation to install such changes into previously sold products.

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